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## Bayesianism and *Apriorism*

By

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### Introduction: The Database Puzzle

I want to start with a puzzle. Many countries now have DNA databases which contain the DNA profiles of large numbers of convicted criminals. The main purpose of these databases is the identification of suspects in police investigations. The following is now a common scenario: a crime is committed, the perpetrator leaves DNA at the crime scene, the investigator finds this DNA and runs it through the database to see if it matches any of the DNA profiles already on it. If there is a match, and the person whose DNA matches that found at the crime scene denies involvement in the crime, then the prosecutor will introduce the evidence of the match at trial. The question which is raised by this scenario is: does the method of generating the match (the database search) reduce the probative value of the DNA evidence? It turns out that commentators cannot agree on how to answer this question.

Two arguments which are used to address the question (and which reach diametrically opposed conclusions) are as follows:

(1) The database search reduces the probative value of the DNA evidence. Imagine having 20 coins and tossing them all into the air at once. They are very unlikely to all land heads up. But repeat the coin tossing enough times and, on at least one throw, they are almost certain to all land heads up. Searching the database is like tossing the coins many times: the larger the database searched, the more likely you are to get a match.

(2) The database search does not reduce the probative value of the DNA evidence. A DNA match is a DNA match is a DNA match. No matter how the match was generated, it tells you the same thing: that the person who matches is unlikely to match if he is innocent. This does not change with the size of the database, just as with the coin tossing the probability of all coins landing heads up *on any one throw* remains constant throughout a long sequence of throws.[\[endnote 1\]](#)

The first argument tends to be used by people who favour the methods of classical statistics. It reflects well-established principles of hypothesis testing. The second argument tends to be used by Bayesians.

So who is right? I am not going to offer a solution to the puzzle at this point. Instead, I want to develop some more general points about Bayesianism and the use of Bayesian methods in the courtroom. Having done that, I will suggest that the solution should be based on principles very different from those adopted by other participants in the debate about database-generated DNA matches.

### Bayesianism in the Courts

I am a conservative fan of Bayesian reasoning. The rigorous analysis it offers provides important insights on the inferences we can draw from evidence. Who could fail to be impressed, for example, by an analysis which helps to show that in certain circumstances a confession will be more probative of innocence than of guilt, or that character evidence can generally not be probative of a defendant's credibility? [\[endnote 2\]](#) It is true that these insights can be gained without using any formula or notation; but the Bayesian analysis makes them clearer, and makes it easier to investigate the circumstances in which the general principles will not hold.

For these reasons I regard Bayesian modelling as a valuable tool for reasoning about evidence. But that is not especially controversial. What is controversial, and what has been rejected by the English courts, is the instruction of fact finders in the use of Bayesian analysis. [\[endnote 3\]](#) Now I am very much aware of the problems, both practical and theoretical, of using Bayesianism in this manner. However, in *Adams*, [\[endnote 4\]](#) the English case where the jury was presented with instruction in the use of Bayes' theorem, the jury faced a difficult task. There was very powerful DNA evidence which inculpated the defendant. But there was also non-scientific evidence (an alibi and a failed eyewitness identification) which tended to exonerate him. The case turned on whether the non-scientific evidence made enough of a dent on the DNA evidence to justify an acquittal. Given that the defendant's case depended on how the jury answered this question, I think that the instruction of the jury in the use of Bayes' theorem can be justified. I have examined this question in some depth elsewhere, so I do not intend to defend that conclusion here. [\[endnote 5\]](#) Instead, I want to pursue a different line of inquiry. If we admit that Bayesianism is a useful and logical way of analysing some evidentiary problems, must we admit, on pain of inconsistency, that it provides an appropriate means of modelling all evidentiary reasoning? And if we support the use of Bayes' theorem in *Adams*, must we support it in all cases? To put it more colloquially, if we give the Bayesians an inch, can we complain if they take a mile?

Consider the following two implications of recognising the logic of Bayesianism which are put forward by Bernard Robertson and Tony Vignaux, two of the leading Bayesian evidence scholars. "If juries are to be instructed in how to apply Bayes theorem to non-scientific evidence in a case where scientific evidence is present," they argue, "there would be no reason why such instruction should not be given in respect of non-scientific evidence alone, that is, in every criminal case." [\[endnote 6\]](#) Robertson and Vignaux also assert that "the reasoning process must conform to Bayesian logic or be wrong. The analogy with a Judge instructing a jury is with a parent teaching a child to ride a bicycle. The parent does not instruct the child consciously to consider the laws of mechanics, but what instruction is given must conform to their requirements." [\[endnote 7\]](#)

Statements such as these reflect what I think is a fairly common mind set among Bayesians, both in law and in other fields. It is an attitude of "*apriorism*", that is to say, the presumption that normative standards for reasoning can be determined *a priori* by reflecting on the principles of probability theory (which Bayesians take to be an extension of the rules of logic). [\[endnote 8\]](#) This is clearly reflected in the quotations from Robertson and Vignaux; they proclaim that good reasoning is that which conforms to logic, and that good reasoning is not context-dependent. According to this view, normative standards are conceptual and are not affected by empirical inquiry.

*Apriorism* is not a philosophy which I find defensible in this context. We can gain some perspective on its flaws by forgetting about reasoning for a moment and looking at two other domains of normative inquiry: linguistics and ethics. [\[endnote 9\]](#) Now there are normative standards of linguistics. Some sentences are grammatical and some are not. Any departure from the rules of grammar would be a legitimate ground for criticising a speaker. But we obviously do not try to determine what the rules are by *a priori* analysis; rather, we examine what people actually say and develop the rules from that empirical inquiry. In ethics, normative standards are not so heavily dependent on empirical inquiry, but that is not to say that empirical inquiry is irrelevant. If we developed ethical standards which we found no person could reach, we would have good grounds for rejecting them. Similarly, though more controversially, some philosophers hold that zoological, evolutionary and neuropsychological inquiry have a wider relevance to normative ethics. [\[endnote 10\]](#)

Just as there are good reasons for not restricting normative inquiry to *a priori* analysis in

linguistics and ethics, so too when it comes to reasoning. Our analysis of norms of reasoning and epistemology should, I think, be naturalised; they should be developed with regard to how people actually reason. [\[endnote 11\]](#) To be more concrete, *apriorism* ignores the following three problems:

(i) *Apriorism* might set standards of good reasoning that no human could ever meet.

(ii) *Apriorism* might set standards of reasoning that we could meet, but which would be very difficult for us to meet because our normal reasoning differs from the norms. This would be rather like being told that, because the language we use has been found to be fundamentally ungrammatical, we must learn to speak a different language. While this would not be impossible, it would be very difficult and possibly inadvisable, since we manage to get by with our current language.

(iii) *Apriorism* might set standards of reasoning that fail to incorporate principles of reasoning that decision makers feel are extremely important for a particular question in issue. Bayesianism has problems recognising and incorporating what is called resilience, or weight, a concept which many (including some Bayesians [\[endnote 12\]](#)) feel is important, especially in legal contexts. Some versions of Bayesianism also hold that we must be prepared to ascribe a probability to any and every proposition. The fact that we are often reluctant to do so suggests, I think, that Bayesianism has it wrong. [\[endnote 13\]](#)

If we abandon *apriorism* and embrace naturalism, there is an obvious objection: that we are opening ourselves to relativism and that we will no longer have any standards with which to judge or criticise reasoning. I suspect that this fear is what makes a zealous Bayesian's *aprioristic* mind set so hard to dent. I think Bayesians are right to worry about destroying evaluative criteria, [\[endnote 14\]](#) but they are wrong to think that abandoning *apriorism* will inevitably lead to this. A quick glance at linguistics and ethics is enough to make this point. Abandoning *apriorism* does not mean that probability theory will no longer be part of our evaluative criteria, only that it will not necessarily be the exclusive or predominant criterion. Naturalism does, however, mean that it will be more difficult to develop evaluative criteria, and that the criteria we adopt may vary between different domains.

### Some Implications of Naturalism

The foregoing analysis has two important implications. First, we should be suspicious of assertions such as "the reasoning process must conform to Bayesian logic or be wrong". There may often be good reasons for a reasoning process not conforming to Bayesian logic; some of them were suggested in (i)-(iii) above. Secondly, using Bayesian methods in the courts to help us with some issues need not mean that we have to use them to help with all our evidentiary reasoning. Consider the situation in a case such as *Adams*. That case was evidentially sparse: there was the DNA evidence, the victim, an alibi witness, and Adams himself. Nothing else. In a case such as this, everything depends on how the non-scientific evidence is integrated with the DNA evidence, but this is not easily accomplished. There is reason to believe that people find reasoning with probabilities difficult, so there are good grounds for presenting them with a framework which will help them to reason with probabilities. [\[endnote 15\]](#) If we conclude that using Bayes' theorem is justified here, then we have reached that conclusion for pragmatic reasons; not because we believe that it is the only logical way to analyse evidence.

### Solving the Database Puzzle

At the beginning of this paper I promised an answer to the DNA database puzzle; it is now time to make good on that promise. Recall that we have two conflicting analyses of the search scenario. One, using the framework of classical hypothesis testing, suggests that the search reduces the probative value of the DNA evidence. The other, Bayesian, approach suggests that it does not. I think that both approaches are right and yet that they are also both wrong. Let me explain. Both are based on fairly logical principles. The fact that they are based on different theories does not make one any better than the other, so both are right. But both are also wrong, because each commits the sin of *apriorism* by assuming that the puzzle can be solved in the abstract. It cannot.

The solution to the database puzzle needs to take into account the way the fact finder is going to analyse the DNA evidence. The presumption behind the Bayesian solution to the problem (that which argues that the database search does not weaken the evidence) is that the fact finder is analysing the case like a rigorous Bayesian. In other words, she starts with a prior probability then multiplies it by likelihood ratios for each piece of evidence presented at trial to reach a posterior probability. If this is what the fact finder does, then the Bayesian solution is indeed appropriate. I find it rather implausible, however, that the fact finder would reason like this, or in any analogous manner. The presumption behind the classical statistical solution to the puzzle (which suggests that the search weakens the evidence) is that the fact finder reasons like a statistician testing hypotheses: considering test results and rejecting them if they do not reach some level of significance. Phrased in this manner, this too seems pretty implausible, but in fact it may not be as unrealistic as the Bayesian model. There is some evidence that in some contexts people do reason in ways analogous to hypothesis testing. [\[endnote 16\]](#) Further, if we consider the jury analysing the case, and if, as some research suggests, juries use "explanation-based decision making", [\[endnote 17\]](#) then, because the database search provides some sort of explanation for the DNA evidence, it would appear to be relevant to the deliberation process. If this is right, then it may be wise to reduce DNA match probabilities in situations where a suspect has been identified by a database search in order to avoid providing the jury with bad character evidence about the defendant (by revealing his presence on the database). [\[endnote 18\]](#)

Whether or not this really is the optimal solution is not particularly important for my present purposes. What is important, and what I think this example demonstrates, is the extent to which attempts to use *a priori* analysis to solve problems of this sort have contributed to a blinkered and unfruitful debate. Like those ancient philosophers who tried to determine how many teeth horses have through abstract argument, rather than by opening a horse's mouth and looking, *apriorists* can contribute only a limited amount to debates about how evidence is best analysed in the courts.

## Endnotes

1. For a summary of the two positions, see D.H. Kaye, *Science in Evidence* (Cincinnati: Anderson Publishing, 1997) 227-30. For more detailed discussions, see National Research Council Committee on DNA technology in Forensic Science: An Update, *The Evaluation of Forensic DNA Evidence* (Washington D.C.: National Academy Press, 1996) 133-5, 161; David J. Balding and Peter Donnelly, "Evaluating DNA Profile Evidence When the Suspect is Identified Through a Database Search" (1996) 41 *Journal of Forensic Sciences*; David J. Balding, "Errors and Misunderstandings in the Second NRC Report" (1997) 37 *Jurimetrics Journal* 469, 470-3; Bernard Robertson and G.A. Vignaux, *Interpreting Evidence: Evaluating Forensic Science in the Courtroom* (Chichester: John Wiley, 1995) 122-7; Newton E. Morton "The Forensic DNA Endgame" (1997) 37 *Jurimetrics Journal* 477, 487-93.
2. See Robert A.J. Matthews, "The Interrogator's Fallacy" (1995) 31 *Bulletin of the Institute of Mathematics and its Applications* 3; Richard D. Friedman, "Character Impeachment Evidence: Psycho-Bayesian [?!] Analysis and a Proposed Overhaul" (1991) 38 *University of California at Los Angeles Law Review* 637.
3. *Adams* [1996] 2 Cr.App.R. 467, and again in *Adams (No. 2)*, [1998] 1 Cr.App.R 377.
4. *supra* note 3. The facts of the case are discussed in more detail in Craig Callen's article, "Adams and the Person in the Locked Room", which appears on this website.
5. I discuss the problem at length in "Presenting Probabilities in Court" (1997) 1 *International Journal of Evidence and Proof* 187.
6. "Explaining Evidence Logically" (1998) 148 *New Law Journal* 159 at 162. The authors do not, in fact, advocate instructing juries in Bayesian reasoning, because, given that this would have to be done in every case to avoid inconsistency, it would cause "vexation, expense and delay".
7. "DNA on Appeal—II" [1997] *New Zealand Law Journal* 247 at 249.

8. On the notion of *apriorism*, see Philip Kitcher, "The Naturalists Return" (1992) 101 *Philosophical Review* 53.
9. The following analysis draws on Edward Stein, *Without Good Reason: The Rationality Debate in Philosophy and Cognitive Science* (Oxford: Clarendon Press, 1996).
10. See Peter Singer (ed.), *Ethics* (Oxford: Oxford University Press, 1994) 5-6, 57-112; Owen Flanagan, "The Moral Network" in Robert N. McCauley (ed.), *The Churchlands and Their Critics* (Oxford: Blackwell, 1996); Alvin I. Goldman, *Philosophical Applications of Cognitive Science* (Boulder: Westview Press, 1993) ch. 5.
11. "Naturalism" is a very vague term and covers many different approaches to normative theorising. I would certainly not go so far as Quine and suggest that normative epistemology should be *replaced* by psychology. See generally Hilary Kornblith (ed.), *Naturalizing Epistemology* 2nd edn (Cambridge, Mass.: MIT Press, 1994). My own views are developed in slightly more detail in "Bayesianism and Proof" in Michael Freeman and Helen Reece (eds), *Science in the Courts* (Dartmouth: Ashgate, forthcoming).
12. See James Logue, *Projective Probability* (Oxford: Clarendon Press, 1995) 87-95, 150-4; Richard Friedman, "Answering the Bayesioskeptical Challenge" (1997) 1 *International Journal of Evidence and Proof* 276, 279.
13. See Mark Kaplan, *Decision Theory as Philosophy* (Cambridge: Cambridge University Press, 1996) pp 23-31 on the "sin of false precision"; cf. Isaac Levi, "Compromising Bayesianism: A Plea For Indeterminacy" in *The Covenant of Reason: Rationality and the Commitments of Thought* (Cambridge: Cambridge University Press, 1997). Both authors reject naturalism, but recognise important constraints which must be built into Bayesianism as it is usually conceived and which restrict its domain of application.
14. Perhaps some commentators would disagree, and would welcome the destruction of conventional evaluative criteria. See Donald Nicolson, "Truth, Reason and Justice: Epistemology and Politics in Evidence Discourse" (1994) 57 *Modern Law Review* 726; cf. Daniel A. Farber and Suzanna Sherry, *Beyond All Reason: The Radical Assault on Truth in American Law* (New York: Oxford University Press, 1997) ch. 5.
15. See Gerd Gigerenzer and Ulrich Hoffrage, "How to Improve Bayesian Reasoning Without Instruction: Frequency Formats" (1995) 102 *Psychological Review* 684; Leda Cosmides and John Tooby, "Are Humans Good Intuitive Statisticians After All? Rethinking Some Conclusions from the Literature on Judgment Under Uncertainty" (1996) 58 *Cognition* 1. The latter suggest that our difficulty in manipulating probabilities may be hard-wired as the result of evolution; both sets of authors argue that people can cope far better with probabilities when they are presented as frequencies. This may suggest a solution to the *Adams* problem, but there are some scenarios in which it might be difficult to present DNA evidence in a frequency format: see J.S. Buckleton, I.W. Evett and B.S. Weir, "Setting Bounds for the Likelihood Ratio When Multiple Hypotheses are Postulated" (1998) 38 *Science and Justice* 23.
16. See Gerd Gigerenzer, Zeno Swijtink, Theodore Porter, Lorraine Daston, John Beatty and Lorenz Krüger, *The Empire of Chance: How Probability Changed Science and Everyday Life* (Cambridge: Cambridge University Press, 1989) 228-9.
17. See Nancy Pennington and Reid Hastie, "The Story Model for Juror Decision Making" in Reid Hastie (ed.), *Inside the Juror: The Psychology of Juror Decision Making* (Cambridge: Cambridge University Press, 1993).
18. Things are a little more complex than this, because we need also to take into account the way in which DNA evidence is presented to the fact finder, as this too will influence her mode of analysis. In England and Wales, the implication of the *Doheny and Adams* ([1997] 1 Cr.App.R. 369) direction on DNA evidence is that the Bayesian solution is preferable. For a more detailed discussion, see Mike Redmayne, "The DNA Database: Civil Liberty and Evidentiary Issues" [1998] *Criminal Law Review* (forthcoming).

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